

DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Transportation Laboratory
5900 Folsom Boulevard
Sacramento, California 95819-4612



METHOD OF TEST FOR DIAMETER OF WIRE AND THICKNESS OF INSULATION (ELECTRICAL CONDUCTORS)

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read “**SAFETY AND HEALTH**” in Section H of this method. It is the responsibility of whoever uses this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed. Users of this method do so at their own risk.

A. SCOPE

This method describes the procedure for determining the thickness of insulation and the diameter of wire on electrical conductors. The insulation testing is a modification of (1) ASTM Designation D-2633 Standard Method of Testing “Thermoplastic Insulated and Jacketed Wire and Cable” and (2) ASTM Designation D-470 “Thermosetting Insulated and Jacketed Wire and Cable”. The conductors must meet (1) ASTM Designation: B-3 Specification for “Soft or Annealed Copper Wire” and (2) ASTM Designation: B8 “Concentric-Lay-Standard Copper Conductors, Hard, Medium-Hard, or Soft”.

B. APPARATUS

1. Machinist’s type micrometer having flat surfaces without locking device constructed with vernier reading to 0.0254 millimeter (mm) and with a ratchet for controlling the measuring pressure.
2. Razor blade knife.

C. TEST AND CALCULATIONS

1. In general, follow the procedure described in Method A of ASTM Designation: D-374. A brief outline is as follows:
 - a. Using a razor blade knife, slice off the top half of the insulation, taking care not to scrape or nick the wire.
 - b. Before starting measurements of thickness, close the micrometer on the specimen at a location outside the area to be measured.
 - c. Open the micrometer no more than 0.127 millimeters and move it to the area selected for measurement.
 - d. Close the micrometer surfaces on the specimen by turning the ratchet so slowly that the scale divisions may be easily counted as they move past the reference mark.
 - e. Continue the closing motion at the same rate until the ratchet has clicked three times or the friction thimble has slipped, and then take the reading of the vernier.

2. To determine insulation thickness and diameter of solid wire, use the following procedure:
 - a. Measure across the conductor and one half of the insulation. This measurement shall be made by slicing off the heavier side of the insulation.
 - b. Cut the insulation back and measure the diameter of the conductor at the same point as the original measurement.
 - c. Subtract the conductor measurement from the reading recorded in 2 (a) to obtain the insulation thickness.
 - d. If the insulation is undersize, take two additional measurements on different sections of the wire and record the average.
 - e. The diameter of the wire is taken as the average of three readings on different sections of the wire.
3. To determine insulation thickness and circular mil area of stranded conductors use the following procedure:
 - a. Determine the diameter of each strand and compute the average diameter. The circular mil area is equal to the (average diameter)² x (no. of strands).
 - b. The insulation thickness shall be determined by laying one strand into the insulation groove, preferably the identical strand removed from that particular groove. Measure over the strand and the insulation wall. Then measure the single strand and subtract this value from the first reading.

If this is measured across the thinnest wall, then this measurement is classified as the minimum thickness.

The average thickness of the insulation shall be taken as one-half

the difference between the mean of the maximum and minimum diameters measured at any point and the average diameter of the conductor measured at the same point.

- c. The area of concentric-lay-standard copper conductors may be determined by either the micrometer or weighing method (ASTM B-263 for Determination of Cross-Sectional Areas of Stranded Conductors).

The area of compact round concentric-lay-stranded copper conductors must be determined by the weighing method as described in ASTM B-263.

D. PRECAUTIONS

1. In moving from one measurement location to another, do not open the micrometer more than 4 to 5 mm above the sampling thickness.
2. In making a measurement, the edges of the micrometer surfaces shall be at least 6.35 mm from the ends of the sample.

E. TOLERANCES

1. For diameters of wire of 0.254 mm and over, the wire shall not vary from the specified diameter (see Table 1, column 2) by more than ± 1 percent expressed to the nearest 0.00254 mm (ASTM B-3, paragraph 4.4).
2. The area of cross section of the stranded conductor shall be not less than 98 percent of the area indicated in column 5 of Table 1 (ASTM B-8, paragraph 11.1).
3. The average thickness of the insulation shall be not less than that prescribed in Table 2, column 2. The minimum thickness shall be not less than 90 percent of the thickness prescribed in Table 2 (ASTM D-2219 and D-2220 paragraph 13.1).

F. SAMPLING

1. When sampling a new reel (single conductor only) the last 1.22 m of wire should be discarded as it has been elongated during manufacturing. A 1-m sample is then taken for testing.
2. When testing a Manufacturer's Lot (one size and one color), the following rule applies:

No. of Reels	No. of Reels in Sample	Allowable No. of Defects
1 to 14, incl.	all	0
15 to 50, incl.	14	0
51 to 100, incl.	19	0
101 to 200, incl.	24	0

See ASTM B-3 Table 2 when the number of reels exceeds 200, or when resampling is required.

G. REPORTING OF RESULTS

Report whether diameter of conductor fails or complies with Special Provisions. Report insulation compliance or failure, but include results of measurement when sample does not comply. This assists the Resident Engineer in making the final decision. Report on Form No. 6039 (Ref. 74).

H. SAFETY AND HEALTH

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual.

Users of this method do so at their own risk.

REFERENCE:

ASTM Designations D-374, D-470, D-2220, D-2633, B-3, B-8, and B-263

End of Test (California Test 635 contains 4 pages)

TABLE 1
Permissible Wire Variations

AWG	Solid Conductor Dia. (mm)			mm ²	98% Min. Area
		—1% Tol.	+1% Tol.		
20	0.813	0.805	0.821	0.661	0.648
18	1.024	1.014	1.034	1.049	1.028
16	1.290	1.277	1.303	1.664	1.631
14	1.628	1.612	1.644	2.650	2.597
12	2.052	2.027	2.077	4.211	4.126
10	2.588	2.562	2.614	6.698	6.564
8	3.263	3.230	3.296	10.647	10.434
6	4.115	4.074	4.156	16.933	16.595
4	5.189	5.137	5.240	26.926	26.387
2	6.543	6.478	6.608	42.811	41.955
1	7.348	7.275	7.421	53.993	52.913
0	8.252	8.170	8.335	68.096	66.734
00	9.266	9.173	9.359	85.859	84.142
000	10.40	10.296	10.504	108.160	105.997
0000	11.684	11.567	11.801	136.516	133.786

TABLE 2
Insulation Thickness

	mm	90% Min.
1/64	0.397	0.357
2/64	0.794	0.715
3/64	1.191	1.072
4/64	1.588	1.429
5/64	1.984	1.786
6/64	2.381	2.143
7/64	2.778	2.143
8/64	3.175	2.858
9/64	3.572	3.215
10/64	3.969	3.572